

HEWLETT-PACKARD COMPANY

Legal Department, 20BN
P.O. Box 10301
Palo Alto, California 94303-0890

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Transmitted herewith for filing under 37 CFR 1.53(b) is a(n): ☒ Utility () Design

☒ original patent application,

() continuation-in-part application

INVENTOR(S): Venkatesh Krishnan, et al.

TITLE: Two Tier Arrangement For Threads Support In A Virtual Machine

Enclosed are:

- ☒ The Declaration and Power of Attorney. () signed ☒ unsigned or partially signed
(X) 3 sheets of drawings (one set) () Associate Power of Attorney
() Form PTO-1449 () Information Disclosure Statement and Form PTO-1449
() Priority document(s) () (Other) (fee \$)

CLAIMS AS FILED BY OTHER THAN A SMALL ENTITY				
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By Patricia Flores
Typed Name: Patricia Flores

Respectfully submitted,

Venkatesh Krishnan, et al.

By Thomas X. Li

Thomas X. Li

Attorney/Agent for Applicant(s)

Reg. No. 37,079

Date: July 9, 1999

Telephone No.: (650) 857-5972

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UNITED STATES PATENT APPLICATION FOR
TWO TIER ARRANGEMENT FOR THREADS SUPPORT
IN A VIRTUAL MACHINE

Inventors:
Venky Krishnan
Geethan Manjunath
Devaraj Das

BACKGROUND OF THE INVENTION

Field of Invention

5 The present invention pertains to the field of software systems. More particularly, this invention relates to a two tier arrangement for threads support in a virtual machine.

Art Background

10 Computer systems and devices having embedded processing resources are typically implemented in a variety of differing architectures. Each architecture is usually defined by a particular instruction set, hardware register set, and memory
15 arrangement, etc. In addition, such computer systems and devices typically include an operating system which is adapted to its particular architecture. The operating system and architecture provide a platform for execution of software tasks.

20 Typically, software tasks such as application programs which are written or compiled to be executed on a particular platform may be referred to as native code. A software task in the native code of a
25 particular platform usually does not run on other non compatible platforms.

30 A virtual machines is a software environment that enables application programs to execute on a variety of differing platforms. The application programs which execute under such a virtual machine usually take the form of a stream of instructions each of which conforms to a predefined instruction

set supported by the virtual machine. A virtual machine implemented on a particular platform typically interprets each of the instructions in the stream and provides emulation of the instructions in the native code of the particular platform. In addition, a virtual machine may include threads support. Threads support may be defined as functionality that enables the parallel execution of multiple software tasks each of which is referred to as a thread.

One example of a virtual machine that enables application programs to execute on a variety of differing platforms and that provides threads support is a Java virtual machine. A typical Java virtual machine functions as an interpreter for Java application programs. A Java application program typically take the form of a stream of Java byte code instructions and the Java virtual machine emulates each Java byte code instruction using the native code of the particular platform under which the Java virtual machine executes. A typical Java virtual machine provides threads support which is defined by the java.lang.Thread class.

A typical virtual machine invokes various services provided by the operating system of the underlying platform including services that provide threads support. Typically, the nature and extent of such operating system services varies among operating systems. For example, some operating systems provide extensive threads support services while other operating systems provide little or no threads

support services. In addition, the details of any
threads support services usually varies widely among
operating systems. Such variation in operating
system services usually complicates the process of
5 adapting a virtual machine to different platforms.
Unfortunately, such complications usually increase
the development time and cost of implementing virtual
machines on different platform. Moreover, such
complications usually increase the cost of software
10 support for virtual machines on different platforms.

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SUMMARY OF THE INVENTION

5 A software system is disclosed with a two tier
arrangement for multi threading in a virtual machine
that enhances the adaptability of the virtual machine
to different platforms. The two tier arrangement
includes a threads interface layer in the virtual
machine and an underlying native threads interface
layer. The threads interface layer includes a set of
10 methods that provide thread support in the virtual
machine according to a standard threads interface
associated with the virtual machine. The native
threads interface layer includes a set of methods
that adapt the methods of the threads interface layer
15 to a platform which underlies the software system.

20 The threads interface layer provides a stable
interface for application programs and other tasks
that benefit from thread support in the virtual
machine. The interactions between the threads
interface layer and the native threads interface
layer are arranged to shield the virtual machine from
the particulars of the underlying operating system,
thereby enhancing portability of the virtual machine
25 and ease of adapting to upgrades in the underlying
operating system.

30 Other features and advantages of the present
invention will be apparent from the detailed
description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described with respect to particular exemplary embodiments thereof and
5 reference is accordingly made to the drawings in which:

Figure 1 shows a software system that includes a two tier arrangement for providing thread support in
10 a virtual machine;

Figure 2 is a state diagram showing the valid states of a thread in one embodiment;

Figure 3 shows a method for providing threads
15 support for a virtual machine in a software system.

DETAILED DESCRIPTION

Figure 1 shows a software system 10 that includes a two tier arrangement for providing thread support in a virtual machine 12 according to the present teachings. The software system 10 may be implemented on wide variety of hardware platforms including computer systems and devices having embedded processing resources.

The virtual machine 12 provides a software environment that enables execution of application programs such as an application program 20 on a wide variety of differing platforms. The virtual machine 12 provides a set of standardized programming interfaces to the application program 20 including standardized interfaces for multi-thread support.

In one embodiment, the virtual machine 12 is a Java virtual machine and the application program 20 is a java application. The following description focuses on an example embodiment in which the virtual machine 12 is a Java virtual machine. Nevertheless, the two tier arrangement for threads support in the software system 10 is readily adaptable to other types of virtual machines.

The software system 10 includes an operating system 18. The operating system 18 together with a particular hardware architecture for which it is implemented provides a platform for the software system 10. The operating system 18 may or may not provide threads support. In addition, any threads

support that may be provided by the operating system 18 may differ in structure and function substantially from the structure and function of threads support defined by the standardized interfaces of the virtual machine 12.

The two tier structure for thread support according to the present techniques is embodied in a threads interface layer (TIL) 14 in the virtual machine 12 and a native threads interface layer (NTIL) 16. The TIL 14 provides a standard threads interface for the virtual machine 12 which does not depend on the underlying platform for the software system 10 while the NTIL 16 is adapted to the particulars of the underlying platform including the operating system 18 which underlies the virtual machine 12.

The two tier structure provided by the TIL 14 and the NTIL 16 enhances the portability of the virtual machine 12 to differing platforms having differing operating systems. For example, the virtual machine 12 may be ported to a different platform in which the TIL 14 provides the standard threads interface to software tasks that execute under the virtual machine 12 and in which an NTIL implemented for the different platform is used to adapt the TIL 14 to the particulars of the operating system of the different platform.

In addition, the two tier arrangement provided by the TIL 14 and the NTIL 16 simplifies adaptation of the virtual machine 12 to changes in threads

support in the underlying functionality of the
operating system 18. For example, the NTIL 16 may be
modified or a new NTIL provided to adapt to the
changes in the operating system 18. The TIL 14
5 remains unchanged and continues to provide the
standard threads interface to the application program
20.

The two tier arrangement for thread support
10 according to the present techniques is illustrated
with respect to a set of threads 30-32 which are
associated with the application program 20. The
threads 30-32 may be defined as relatively small
processes that share an address space and that are
15 executed by the virtual machine 12 in parallel. The
parallel execution may involve context switching
among the threads 30-32 if the hardware platform for
the software system 10 provides a single processor
architecture. Alternatively, the threads 30-32 may
20 execute concurrently if the hardware platform for the
software system 10 provides a multi-processor
architecture or a multi-thread processor in hardware.

The functions performed by the threads 30-32
25 generally depend on the nature of the application
program 20. For example, if the application program
20 services a communication socket which receives
hypertext transfer protocol (HTTP) commands then each
thread 30-32 may have been created to handle a
30 different HTTP command received via the communication
socket.

In addition to threads created by application programs, there may be threads associated with the functionality of the virtual machine 12 such as threads associated with a garbage collection task or just-in-time compiler task to name a few examples. These are just a few examples of the use of threads and it will be appreciated that there are numerous other uses for threads in the software system 10.

Each of the threads 30-32 has a context in terms of the virtual machine 12 and a context in terms of the underlying platform of the software system 10 including the operating system 18. The TIL 14 maintains the context the threads 30-32 in terms of the virtual machine 12. In one embodiment, the context of a thread in terms of the virtual machine 12 includes values in the interpreter registers in a Java virtual machine, i.e. the SP, PC, FP, LVP and NPC registers, and the base of the Java stack. The NTIL 16 maintains the context of the threads 30-32 in terms of the underlying platform of the software system 10. The context of a thread in terms of the underlying platform includes values of the machine registers in the underlying processor and the native stack of the underlying platform.

The TIL 14 provides support in the virtual machine 12 for spawning multiple threads such as the threads 30-32. In one embodiment, the TIL 14 is an implementation of the methods in the Java threads class `java.lang.Thread` and each of the threads 30-32 is viewed by the TIL 14 as a Java thread object. A Java thread object is an object that implements the run-

able interface of Java application programming interface (API). The following is a list of the methods in the Java threads class in one embodiment.

5 run()
start()
stop()
suspend()
resume()
10 getThreadGroup()
getPriority()
setPriority()
isDaemon()
setDaemon()
countStackFrames()
15 join()
interrupt()
isInterrupted()
interrupted()
currentThread()
20 activeCount()
enumerate()
dumpStack()
yield()
sleep()
25 destroy()

The methods in the TIL 14 have analogous methods in the NTIL 16 which are adapted to the underlying platform of the operating system 10. For example, the TIL 14 provides methods for spawning the threads 30-32 in terms of the virtual machine 12. The NTIL 16 includes analogous methods for spawning user level threads for the threads 30-32 in terms of the underlying platform of the software system 10. Similarly, the TIL 14 includes methods for suspending and resuming Java threads in terms of the virtual machine 12 and the NTIL 16 includes analogous methods of suspending and resuming the corresponding user level threads in terms of the platform that underlies the software system 10.

In the example embodiment, the spawn functionality of the TIL 14 is provided by an

implementation of the start() method of the Java
threads class. The spawning of a Java thread by the
TIL 14 includes the allocation of the Java stack and
initialization of the virtual machine registers SP,
5 PC, FP, LVP and NPC for the Java thread. This
creates the Java virtual machine context for the Java
thread. The TIL 14 then uses analogous methods in
the NTIL 16 to spawn a user level thread in terms of
the underlying platform of the software system 10.
10 The TIL 14 associates the user level thread created
by the NTIL 16 to the Java thread.

The following illustrates the context of each
thread 30-32 in terms of the virtual machine 12 in
15 the example embodiment.

	JVM_byte	*pc;	> current program counter
	JVM_byte	*npc;	> next program counter
	int	sp;	> top of Java app stack
20	int	lvp;	> local variable pointer
	int	fp;	> frame pointer
	JVM_word	*stack;	> base of Java app stack
	char	*refstk;	> base of the reference stack
25	jmp_buf	jbuf;	> jump buffer for external exceptions

In one embodiment, the thread support methods in
the NTIL 16 are as follows.

Thread threadCreate(...)
30 int threadSuspend(Thread)
int threadResume(Thread)
int threadJoin(Thread)
int threadYield()
int threadStop(Thread)
35 int threadSetPrio(Thread)
int threadGetPrio(Thread)
int threadCurrent()
int scheduler()

40 The NTIL 16 provides an API for the above-listed
methods to the TIL 14. The methods in the TIL 14 use
this API to send requests to the methods in the NTIL

16 to perform the particular threads functions in terms of the underlying platform of the software system 10. The API to the NTIL 16 is independent of the underlying platform for the software system 10 and is independent of the particular implementations of the methods in the NTIL 16. The following sets forth one possible embodiment of the methods in the NTIL 16.

The following structure is used to define a user level thread in the context of the underlying platform for the software system 10. PTHREAD refers to a user level thread in terms of the underlying operating system 18.

```
typedef struct thread_t{
    Lock      lock;          /* Lock for this thread structure
                             */
    pthread_t pthr_id;       /* The id of the corresp. PTHREAD
                             */
    Utf8Const *name;         /* The thread name */
    JVM_word  state;         /* The tread state */
    Object     *thrObj;      /* Object corresp. to this thread
                             */
    VmContext vm;           /* Ptr to Virt. Mach. Rntime Info
                             */
    Thread_t  *nest;
} * Thread;
```

The NTIL 16 uses Thread as a pointer to a thread structure for a user level thread. Thread is an unsigned integer that is used as a thread identifier by the NTIL 16. The NTIL 16 maintains a global thread list (GTL) which is a linked list of all user level threads. One global lock is used for adding or deleting thread structures from the GTL. A thread identifier for a currently running thread is maintained in a global variable which changes every

time the scheduler() method chooses to schedule another thread.

5 In this example embodiment, the NTIL 16 performs a context switch using a swapcontext() routine which is provided in a C implementation in the operating system 18. The swapcontext() routine swaps the internal registers and stack associated with the particular processor of the underlying platform of the software system 10.

15 **Figure 2** shows a state diagram for the threads 30-32 in one embodiment. The valid states of the threads 30-32 include a READY state, a SUSPENDED state, a RUNNING state, and a DEAD state. The state diagram shows the transitions among the states caused by the thread support methods in the NTIL 16.

20 The method threadCreate() creates a new user level thread by allocating a thread structure and calling threadSpawn().

25 Thread threadCreate(void* (*startRoutine)(void*), void *a rgs, Object *thrObj, Utf8Const *name)
{
Allocate a Thread structure.
Grab the lock for the global thread list (GTL).
Fill in the defaults into the new Thread structure.
Attach the current structure to the GTL.
30 Set Thread State to READY.
threadSpawn(&pthr_id, startRoutine, arguments);
Return the lock for the GTL.
Return the pointer to the Thread Structure.
35 }

The method threadSuspend() suspends the specified thread.

int threadSuspend(Thread t)

```

{
    Lock thread struct
    Set state of t to SUSPEND
    if (t is currentThread){
5         Unlock
          scheduler()
    }
    else
10     Unlock
}
```

The method threadResume() resumes the specified thread.

```

15 int threadResume(Thread t)
   {
       if (t is currentThread)
           return
       Lock thread struct
20       if (state of t is SUSPENDED)
           Set state of t to READY
       Unlock thread struct
   }
```

25 The method threadJoin() waits for completion of the specified thread.

```

int threadJoin(Thread t)
{
30     if (t is currentThread)
        return
    check:
        Lock Thread Struct
        if (State of t is DEAD)
35         Unlock and return

        Attach on the thread wait set
        Unlock
        threadSuspend(currentThread)
40         toto check;
}
```

```

int threadJoinTimeOut(Thread t, long msec)
{
45     if (t is currentThread)
        return
    check:
        Lock Thread Struct
        if (State of t is DEAD)
50         Unlock and return

        Attach on the thread wait set
        Unlock
```


}

The method `threadYield()` yields the execution, i.e. processor time, to some other thread.

10

15

20

25

The method `threadSetPrio()` sets the priority of the specified thread.

35

40

45

```
    prio = priority of t
    Unlock
    return prio;
}
```

5

The method `threadCurrent()` returns the identifier of the currently running thread.

```
int threadCurrent()
{
    return currentThread;
}
```

10

The method `scheduler()` selects a thread for execution.

15

```
int scheduler()
{
    Lock the GTL
    c= Select the highest priority READY thread from the
    (list)
        queue.
    T = currentThread;
    if (c == t)
    25     return;
    if (c == NULL)
        Fatal Error : Dead Lock Condition
    Set state of c to RUNNING
    Put c in the state of list.
    set currentThread = c
    30     if (state of t is RUNNING)
        Set state of t to READY
    Attach t to appropriate place in list.
    Unlock GTL
    35     threadContextSwitch(t,c);
}
```

```
threadContextSwitch(Thread from,Thread to)
{
    40     switchVMachineContext(from,to)
    /*
        Make sure that out of all the pthreads corresponding to
        Java threads only one pthread is READY at any given
    time.
    45     This ensures the actual scheduling of the required Java
        application thread.
    */
    pthread_continue(to.pthr_id);
    pthread_suspend(from.pthr_id);
    50 }
}
```

```
threadSpawn(pthr_id, void* (*startRoutine)(void*), void
*arguments)
```

```
{  
    Call pthread_create(&pthr_id,startRoutine,arguments)  
}
```

5 In some embodiments, the native thread support
routines of the NTIL 16 take advantage of thread
support routines that exists in the operating system
18. For example, some UNIX operating systems and the
LINUX operating system include an implementation of
10 pthreads which may be used by the NTIL 16. This is
illustrated by the example embodiment in which the
operating system 18 includes the thread support
routines pthread_create() and pthread_continue() and
pthread_suspend() which are invoked by the routines
15 threadContextSwitch() and threadSpawn() of the NTIL 16.
The routine pthread_create() creates a new thread in the
context of a processor under which the operating
system 18 executes at a specified address. The
routine pthread_create() is used to start a new
20 execution context and it returns a thread identifier
pthr_id for the new native thread. The routine
pthread_suspend() takes a thread identifier pthr_id as an
argument and is used to suspend the specified native
thread. The routine pthread_continue() takes a thread
25 identifier pthr_id as an argument and is used to
resume the specified native thread.

 In other embodiments of the software system 10,
the operating system 18 provides thread support
30 routines that perform equivalent functions to one or
more of the native thread support routines of the
NTIL 16. In such embodiments, the equivalent native
thread support routines of the NTIL 16 perform a call
to the appropriate thread support routine in the
35 operating system 18. For example, if the operating

system 18 includes a thread scheduler routine that performs the equivalent function of the scheduler() routine in the NTIL 16, then the scheduler() routine in the NTIL 16 calls the thread scheduler routine of the operating system 18. Other native thread support routines may be fully coded in the NTIL 16 if equivalents are not available in the operating system 18.

In other embodiments, one or more of the native thread support routines may be fully coded in the NTIL 16 whether or not equivalents are provided in the operating system 18. This insulates the NTIL 16 from changes to thread support in the underlying operating system 18.

Figure 3 shows a method for providing threads support for a virtual machine in a software system. The method steps shown may be used to adapt the virtual machine to a new platform or to adapt the virtual machine to changes in the underlying platform such as changes to the underlying operating system and/or hardware.

At step 100, a threads interface layer is implemented in the virtual machine. The threads interface layer includes a set of methods that provide thread support according to a standard threads interface associated with the virtual machine. The methods in the threads interface layer maintain a set of context information for each of a set of threads in the software system in terms of the virtual machine.

At step 102, a native threads interface layer is implemented. The native threads interface layer includes a set of methods that adapt the methods of the threads interface layer to the platform which underlies the software system. The methods in the native threads interface layer maintain a set of context information for each of a set of threads in the software system in terms of the platform. Step 102 may be used to adapt the virtual machine to changes in the underlying platform for a given virtual machine.

The foregoing detailed description of the present invention is provided for the purposes of illustration and is not intended to be exhaustive or to limit the invention to the precise embodiment disclosed. Accordingly, the scope of the present invention is defined by the appended claims.

CLAIMS

What is claimed is:

- 5 1. A software system with a two tier arrangement
for threads support, comprising:
 virtual machine including a threads interface
layer having a set of methods that provide thread
support in the virtual machine according to a
10 standard threads interface associated with the
virtual machine;
 native threads interface layer that provides a
set of methods that adapt the methods of the threads
interface layer to a platform which underlies the
15 software system.
2. The software system of claim 1, wherein the
standard threads interface is a Java threads class.
- 20 3. The software system of claim 1, wherein the
threads interface layer maintains a set of context
information for each of a set of threads in the
software system in terms of the virtual machine.
- 25 4. The software system of claim 3, wherein the
context information includes a value for each of a
set of virtual machine registers associated with
corresponding thread.
- 30 5. The software system of claim 1, wherein the
native threads interface layer maintains a set of
context information for each of a set of threads in
the software system in terms of the platform.

6. The software system of claim 5, wherein the context information includes a value for each of a set of processor registers associated with the platform.

5

7. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to suspend a particular thread.

10

8. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to resume a particular thread.

15

9. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to wait for completion of a particular thread.

20

10. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to yield execution to another thread.

25

11. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to stop an execution of a particular thread and to clean up a set of structures associated with the particular thread.

30

12. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to set a priority of a particular thread.

5

13. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to obtain a priority of a particular thread.

10

14. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to obtain an identifier of a currently executing thread.

15

15. The software system of claim 1, wherein the native threads interface layer includes a method that enables the threads interface layer to select a thread for execution.

20

16. A method for providing threads support for a virtual machine in a software system, comprising the steps of:

25 providing a threads interface layer in the virtual machine including a set of methods that provide thread support according to a standard threads interface associated with the virtual machine;

30 providing a native threads interface layer having a set of methods that adapt the methods of the threads interface layer to a platform which underlies the software system.

17. The method of claim 16, wherein the methods in the threads interface layer perform the step of maintaining a set of context information for each of a set of threads in the software system in terms of the virtual machine.

18. The method of claim 17, wherein the step of maintaining a set of context information comprises the step of maintaining a value for each of a set of virtual machine registers associated with corresponding thread.

19. The method of claim 16, wherein the methods in the native threads interface layer perform the step of maintaining a set of context information for each of a set of threads in the software system in terms of the platform.

20. The method of claim 19, wherein the step of maintaining a set of context information comprises the step of maintaining a value for each of a set of processor registers associated with the platform.

21. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of suspending a particular thread.

22. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of resuming a particular thread.

23. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of waiting for completion of a particular thread.

5

24. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of yielding execution to another thread in response to a request from one or more of the methods in the threads interface layer.

10

25. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the steps of stopping execution of a particular thread and cleaning up a set of structures associated with the particular thread.

15

26. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of setting a priority of a particular thread.

20

27. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of obtaining a priority of a particular thread.

25

28. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of obtaining an identifier of a currently executing thread.

30

29. The method of claim 16, wherein the methods in the native threads interface layer include a method that performs the step of selecting a thread for execution.

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ABSTRACT

5 A software system with a two tier arrangement
for threads support that enhances the adaptability of
a virtual machine to differing platforms. The
software system includes a virtual machine with a
threads interface layer having a set of methods that
provide thread support in the virtual machine
according to a standard threads interface associated
with the virtual machine. The software system
10 includes a native threads interface layer that
provides a set of methods that adapt the methods of
the threads interface layer to a platform which
underlies the software system. The native threads
interface layer shields the virtual machine from the
15 particulars of the underlying operating system while
the threads interface layer provides a stable
interface for application programs and other tasks
that benefit from thread support in the virtual
machine.

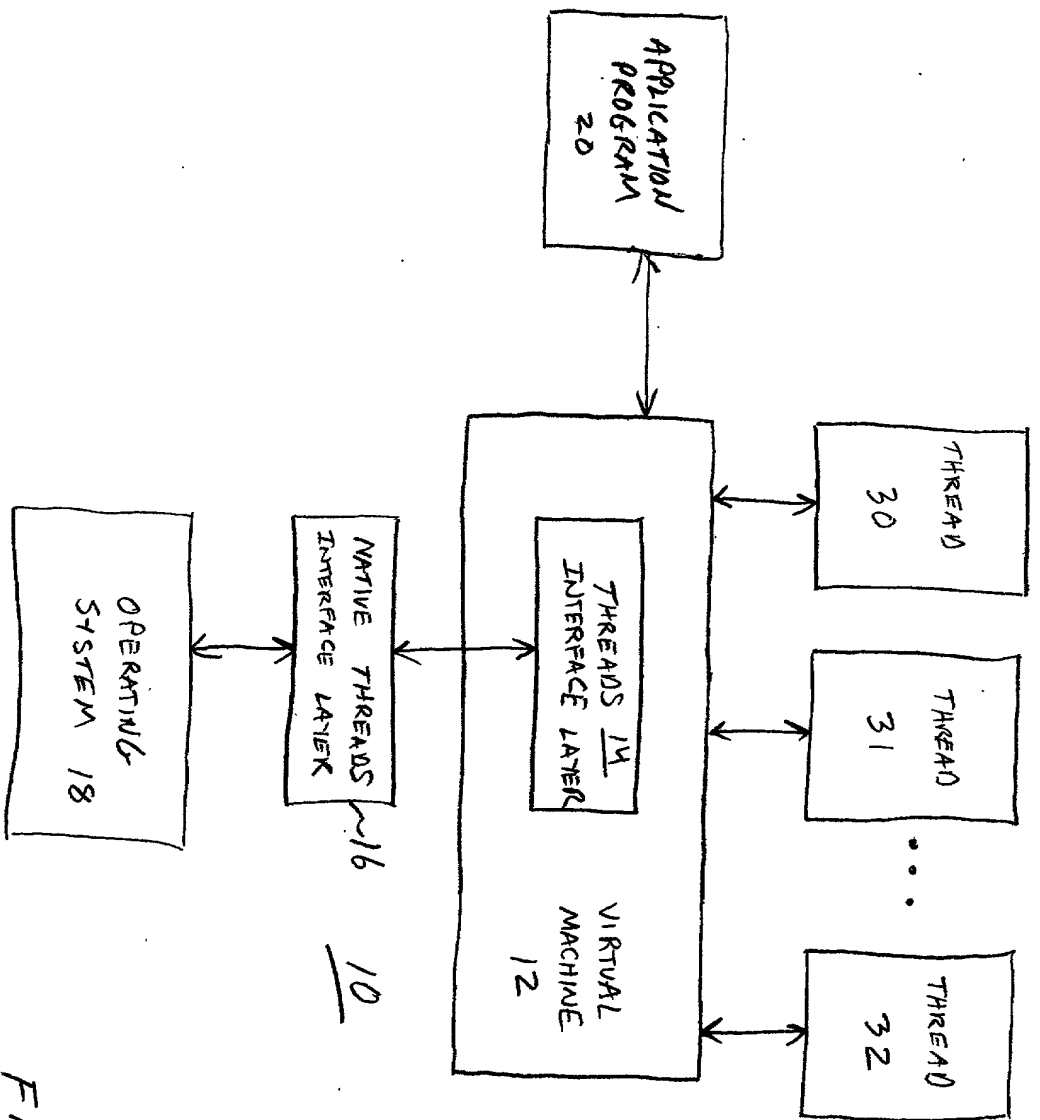


FIG 1

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Fig 2



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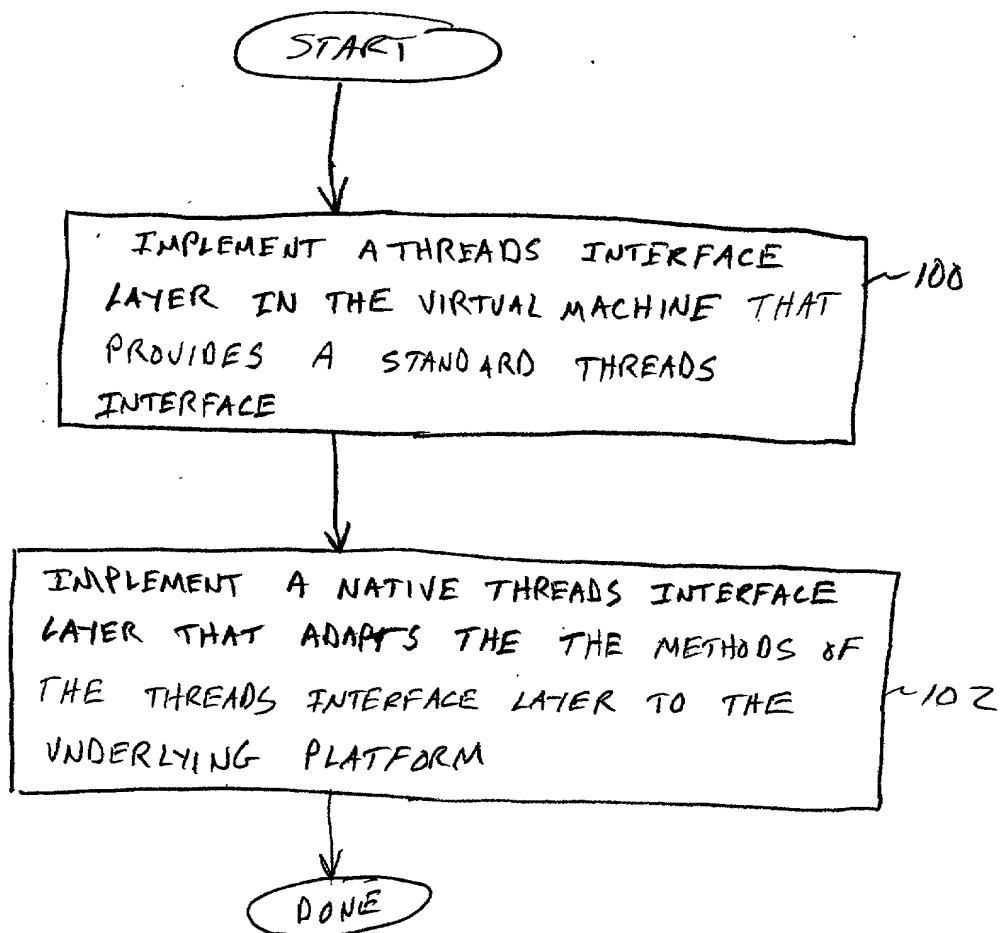


FIG 3

10981455

DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATIONATTORNEY DOCKET NO. 10981455-1

As a below named inventor, I hereby declare that:

My residence/post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Two Tier Arrangement For Threads Support In A Virtual Machine

the specification of which is attached hereto unless the following box is checked:

() was filed on _____ as US Application Serial No. or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understood the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose all information which is material to patentability as defined in 37 CFR 1.56.

Foreign Application(s) and/or Claim of Foreign Priority

I hereby claim foreign priority benefits under Title 35, United States Code Section 119 of any foreign application(s) for patent or inventor(s) certificate listed below and have also identified below any foreign application for patent or inventor(s) certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE FILED	PRIORITY CLAIMED UNDER 35 U.S.C. 119
			YES: _____ NO: _____
			YES: _____ NO: _____

Provisional Application

I hereby claim the benefit under Title 35, United States Code Section 119(e) of any United States provisional application(s) listed below:

APPLICATION SERIAL NUMBER	FILING DATE

U. S. Priority Claim

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NUMBER	FILING DATE	STATUS (patented/pending/abandoned)

POWER OF ATTORNEY:

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) listed below to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Thomas X. Li**Edward Y. Wong****Marc P. Schuyler****Timothy R. Croll**Reg. No. **37,079**Reg. No. **29,879**Reg. No. **35,675**Reg. No. **36,771**

Send Correspondence to:
IP Administration
Legal Department, 20BN
HEWLETT-PACKARD COMPANY
P.O. Box 10301
Palo Alto, California 94303-0890

Direct Telephone Calls To:

Thomas X. Li
(650) 857-5972

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Inventor: **Venkatesh Krishnan**Citizenship: **US**Residence: **710 Russett Terrace, Sunnyvale CA 94087**Post Office Address: **Same as residence**

Inventor's Signature _____

Date _____

**DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION (continued)**

ATTORNEY DOCKET NO. 10981455-1

Full Name of # 2 joint inventor: Geetha Manjunath Citizenship: IN
Residence: No 202, 14th Main, BSK I Stage, II Block, Bangalore 560050, INDIA
Post Office Address: Same as residence

Inventor's Signature _____ Date _____

Full Name of # 3 joint inventor: Devaraj Das Citizenship: IN
Residence: 10, Esawara Layout, Indiranagar 2nd Stage, Bangalore 560038, India
Post Office Address: Same as residence

Inventor's Signature _____ Date _____

Full Name of # 4 joint inventor: _____ Citizenship: _____
Residence: _____
Post Office Address: _____

Inventor's Signature _____ Date _____

Full Name of # 5 joint inventor: _____ Citizenship: _____
Residence: _____
Post Office Address: _____

Inventor's Signature _____ Date _____

Full Name of # 6 joint inventor: _____ Citizenship: _____
Residence: _____
Post Office Address: _____

Inventor's Signature _____ Date _____

Full Name of # 7 joint inventor: _____ Citizenship: _____
Residence: _____
Post Office Address: _____

Inventor's Signature _____ Date _____

Full Name of # 8 joint inventor: _____ Citizenship: _____
Residence: _____
Post Office Address: _____

Inventor's Signature _____ Date _____